9. *Fish Consumption*

9.1 *Introduction*

The "Hot Spots" (AB-2588) risk assessment process addresses contamination of bodies of water, mostly fresh water, near facilities emitting air pollutants. The consumption of fish from contaminated bodies of water can be a significant exposure pathway, particularly for lipophilic toxicants such as dioxins. Commercial store-bought fish generally come from a number of sources. Thus, except in the rare event that fish in these bodies of water are commercially caught and eaten by the local population, the health risks of concern are due to noncommercial fishing. Therefore, the noncommercial fish consumption rate is a critical variate in the assessment of potential health risks to individuals consuming fish from waters impacted by facility emissions. The term "fisher" refers to persons who catch noncommercial fish or shellfish. The term fisher may include both subsistence and sport fishers, but also may include others who do not fit easily into these categories.

It should be noted that the AB-2588 risk assessment process currently addresses contamination of fish only by bioconcentration and not by bioaccumulation. Bioconcentration is the purely physical-chemical process by which chemicals tend to apportion themselves between water and fish lipids, depending on the lipophillicity of the chemical. Bioaccumulation is the process through which chemical concentrations in fish increase as the chemical moves up the food chain. This process occurs because there are fewer organisms feeding off of more organisms at each level in the food chain, thus concentrating the chemical contaminants. The bioaccumulation process may cause higher fish contaminant concentrations than bioconcentration. The AB-2588 program is currently investigating the feasibility of applying the models for bioaccumulation which currently exist (Thomann et al., 1991) to the risk assessment process. It should be noted that on-site information on the fish species caught and its position in the food chain would have to be collected to assess bioaccumulation.

Estimates of noncommercial fish consumption by fishers tend to be comparable or greater than estimates of commercial fish consumption rates for the general population (Puffer et al., 1982a-b; SCCWRP and MBC 1994; U.S. EPA, 1994). The higher intake rate of noncommercial fish consumption by fishers creates a sensitive subpopulation relative to the general population when a facility's emissions impact a fishable body of water. Because noncommercial fish consumption rates may vary by geographic location and for specific subpopulations, the U.S. EPA recommends using data on local consumption patterns and population characteristics whenever possible (U.S. EPA, 1994). For instance, subsistence fishers, as well as certain cultural groups, can have particularly high consumption rates relative to the general population (U.S. EPA, 1994). Use of national averages can seriously underestimate risks to these subpopulations.

The majority of bodies of water impacted by facility emissions are freshwater. Although regional air contaminants depositing into the ocean, bays and estuaries are a significant problem, the risks predicted from a single source are relatively insignificant due to tidal flows and dilution. Since most of the contaminated bodies of water of concern in the "Hot Spots" program are freshwater, the ideal study to use to determine consumption rates would be a study of California freshwater noncommercial fish consumption. Unfortunately, there are no such studies available. However, comprehensive studies have been conducted in California surveying consumption rates of saltwater fishers (Puffer et al., 1982a-b; SCCWRP and MBC, 1994). These studies encountered an ethnically diverse array of fishers, which may better approximate the consumption patterns for the California population, relative to studies that surveyed more homogeneous populations. Based on a comparison between these studies and consumption surveys conducted in the Great Lakes, it appears that the consumption rates and distributions between fresh and saltwater fishers are consistent.

In the "Hot Spots" program, cancer risks from various exposure pathways are summed to determine an overall cancer risk to the population exposed by a facility. This is done despite the fact that while all of the people living within the zone of impact are exposed by the inhalation pathway, only some of the people in the zone of impact are likely to be exposed through consumption of noncommercial fish (or homegrown produce or meat). Therefore, the summation of cancer risks reflects theoretical cancer risks to the individuals living within the zone of impact that have exposure via all the pathways included in the risk assessment.

OEHHA recognizes that the distributions and single point estimates for noncommercial fish consumption for the fisher subpopulation cannot fit all situations addressed by the Air Toxics "Hot Spots" program. Demographics, socio-economic factors, fish yield, presence or absence of fish stocking, availability of alternative bodies of water and local climate are other factors which could cause higher or lower noncommercial fish consumption than the OEHHA estimates. However, conducting a site-specific noncommercial fish consumption survey in most cases, would not be a cost-effective alternative to use of the values presented in this chapter. However, factors which might significantly reduce or increase the estimated quantity of noncommercial fish consumed should be described in the risk assessment.

9.2 Algorithm for Dose via Fish Ingestion

In the Air Toxics "Hot Spots" program, the concentration in fish, Cf, is a product of the modeled concentration in water and the bioconcentration factor for the chemical of concern.

$$Cf = Cw \times BCF \qquad \text{(Eq. 9-1)}$$

where: Cf = concentration in fish (μg/kg)
Cw = concentration in water (μg/kg)
BCF = chemical-specific bioconcentration factor for fish

Airborne contaminants can deposit directly into a body of water or be carried there by runoff. The current Air Toxics "Hot Spots" algorithm only considers direct deposition. This is due to 1) the complexity of accounting for chemicals deposited on surfaces in the watershed of a body of water and then carried into that water by runoff, and 2) the relatively small impact of the fish ingestion pathway in the facility-specific risk assessments conducted for the Air Toxics "Hot Spots" program. On a regional basis, there is little doubt airborne chemicals contribute significantly to water contamination. However, when evaluating risks posed by emissions from a specific facility, the contribution from noncommercial fish ingestion tends to be small and is generally considerably smaller than the inhalation pathway. The majority of facilities in the Air Toxics "Hot Spots" program do not impact fishable bodies of water. The failure to account for runoff will tend to underestimate risk in some cases. However, in order to assess runoff extensive (and expensive) on-site data would have to be collected. The concentration in the water in the much simpler model recommended here is a function of what is directly deposited into the body of water. This is calculated as follows:

$$Cw = Dep\ (SA)\ (365)\ /\ (WV)\ (VC) \qquad \text{(Eq. 9-2)}$$

where:

Cw =	concentration in water (µg/kg)
Dep =	amount deposited/day ($\mu g/m^2$/day) = GLC x dep-rate x 86,400
GLC =	modeled ground level concentration ($\mu g/m^3$)
dep-rate =	vertical rate of deposition (m/sec)
86,400 =	seconds/day
SA =	surface area of water body (m^2)
365 =	days per year
WV =	water volume (L = kg)
VC =	number of volume changes per year

The deposition rate is assumed to be 0.02 m/sec for a controlled source and 0.05 m/sec for an uncontrolled source (see Chapter 2). The terms SA, WV, and VC are site-specific factors; values for these terms need to be ascertained by the risk assessor.

There are a number of methodological difficulties in evaluating BCF. In addition, the BCF for one species of fish may not apply to another. OEHHA has utilized outside expertise in choosing BCF values to use for site-specific risk assessment (Cohen, 1996). The results of the expert evaluations are provided in Appendix H.

Calculating dose of contaminant via fish ingestion requires an estimate of the fish concentration and the amount of fish an individual consumes. The following equation can be used to calculate dose via ingestion of contaminated fish:

$$\text{Dose} = (\text{Cf} \times I_{fish} \times \text{GI} \times \text{L} \times \text{EF} \times \text{ED}) / (\text{AT} \times 10^6) \qquad \text{(Eq. 9-3)}$$

where:
Dose = dose of contaminant via ingestion of fish (mg/kg-day)
Cf = concentration in fish (μg/kg)
I_{fish} = noncommercial fish ingestion rate (g/kg BW-day)
GI = gastrointestinal absorption fraction, unitless
L = fraction of noncommercial fish caught at contaminated site, unitless
EF = Exposure frequency (days/year)
ED = Exposure duration exposure duration (years)
AT = Averaging time; time period over which exposure is averaged in days (e.g. 25,550 days for 70 years for carcinogenic risk calculations)
10^6 = conversion factor (μg/mg) (kg/gm)

The value of Cf is calculated using equations 9-1 and 9-2. The gastrointestinal absorption fraction is generally 1 because the reference exposure levels and cancer potency factors are rarely adjusted for absorption. In addition, data do not usually exist to adjust absorption in humans from fish. The factor, L, is a site-specific factor; the risk assessor must evaluate site-specific data to ascertain what fraction of the noncommercial fish consumed by an individual comes from the impacted body of water. If such data are unobtainable, then L should be set to 1. We provide both point estimates and a distribution of noncommercial fish consumption rates normalized to body weight at the end of this chapter.

9.3 Studies Evaluated for Noncommercial Fish Consumption Rate

OEHHA conducted a comprehensive review of available studies on consumption of fish and shellfish in the United States and in California inclusive of national (general population) surveys as well as studies focusing on fishers (Gassel, 1996). Studies which measured consumption of commercially purchased fish were not applicable to site-specific risk assessment in the Air Toxics “Hot Spots” program because, as noted above, consumption of commercially purchased fish is, for the vast majority of facilities, not an exposure pathway that needs consideration in the “Hot Spots” program.

The most recent comprehensive study of noncommercial fish consumption in California is the Santa Monica Bay Seafood Consumption Study (SCCWRP and MBC, 1994). This study was undertaken to describe the demographic characteristics of fishers that fish the Santa Monica Bay, to assess their noncommercial seafood consumption rates, and to identify ethnic subgroups that may have high rates of seafood consumption. Surveys were conducted at 29 sites on 99 days, from September 1991 to August 1992. Fishers on piers and jetties, private boats, party boats, and beaches were interviewed using a questionnaire. Interviewers were able to administer the questionnaire in English, Spanish, and Vietnamese. One interviewer also spoke Chinese and

Tagalog. This study focused on consumption of 8 common species of fish, but consumption of other types of fish was also quantified. Among the survey questions, fishers were asked to estimate how much of a species he/she consumed per meal, compared to a wood model representing a 150 gram (0.33 pound) portion of a fish fillet. In addition, fishers were asked the number of times they had consumed each of the species in the 4 weeks prior to the interview. The latter estimate of noncommercial fish consumption was not limited to sport fish from the Santa Monica Bay, but specifically excluded fish purchased from a store. Fishers who had eaten any of the 8 species in the survey in the 4 weeks prior to the interview were included in consumption rate estimates. Of the 1,243 fishers interviewed, 554 provided information that could be used for calculating consumption rates. Average daily noncommercial fish consumption rates (g/day) were calculated by multiplying the fisher's estimate of the typical meal size relative to the model, by the frequency of consumption in the four weeks prior to the interview, divided by 28 days.

In 1980, an intercept survey was conducted in the Los Angeles metropolitan area (including Santa Monica Bay) to assess noncommercial fish and shellfish consumption rates by local fishers, and to identify subgroups that have significantly larger consumption rates (Puffer et al., 1982a-b). The intercept survey method surveys fishers at a fishing site or sites about fish consumption, catch or other questions of interest. During the one-year study period, a total of 1,059 fishers were interviewed at 12 sites, including piers, jetties, and party boats. Average daily consumption rates were estimated based on the number of fish in the catch, the average weight of the fish in the catch, the edible portion of the species, the number of fish eaters in the family and the frequency of fishing per year. While this study was quite extensive, providing consumption data from over 1,000 individuals representing various ethnic groups in the survey population (i.e., Caucasian, Black, Mexican-American, and Oriental/Samoan), only English speaking fishers were included in the study. In addition, seafood consumption patterns may change over time. The Santa Monica Bay Fish Consumption Study was more recent and interviewed a number of different ethnic groups in their native languages.

The fish consumption rate distribution generated in the Puffer et al. (1982a-b) study has been criticized by U.S. EPA (1997) for failure to take into account avidity bias. Price et al. (1994) examined the problem in two creel surveys conducted by Pierce et al. (1981) and Puffer et al. (1981). Avidity bias arises in creel surveys because an individual who fishes frequently has a greater chance of being interviewed than a person who fishes infrequently. Thus the distribution will over-represent the consumption of frequent fishers. Price et al. (1994) attempted to correct for the bias by assigning sampling weights for each individual as the inverse of fishing frequency. When this procedure is applied to the fish consumption distribution of Puffer et al. (1982a-b) the median and 90^{th} percentile are adjusted from 37 and 225 g/day to 2.9 and 35 g/day, respectively. The mean and 95^{th} percentile were not discussed by Price et al (1994). The SCCWRP and MBC, 1994 study is not discussed by U.S. EPA (1997) or by Price et al. (1994), but the survey methodologies are similar and the study did not take into account avidity bias.

The methodology that Price et al. (1994) used to adjust the Puffer et al. (1982a-b) and Pierce et al. (1981) studies was criticized by U.S. EPA (1997) as underestimating fish consumption. Price et al. (1994) assign sampling weights based on the inverse frequency of fishing, which U.S. EPA (1997) points out is not strictly proportional to the probability of sampling as the number of sampling days increases. However, U.S. EPA (1997) does state that the estimates of Price et al. (1994) are probably better estimates of the fish consumption of the entire population that fishes the area than the nonadjusted survey results. OEHHA was not able to determine the exact procedure that Price et al. (1994) followed from the information presented in the paper. We could not therefore assess the validity of the procedure.

West et al. (1989a-c) conducted a stratified random survey of Michigan residents with annual fishing licenses. Those with one day fishing licenses from both in state and out of state were excluded thus eliminating some infrequent fishers. The West et al. (1989a-c) study included children and other family members in the survey. The researchers did not generate a distribution but determined a mean of 16.1 g/d for sport fish consumption. The probability of being contacted in this study was not dependent on the frequency of fishing; therefore, the avidity bias found in intercept surveys is not present in the data. However, it is possible that avid anglers were more frequently represented among respondents that returned surveys.

Murray and Burmaster (1994) used the raw data of West et al. (1989a-c) to generate a distribution for total fish and noncommercial fish. Burmaster et al. (1994) used the short-term data for adults to generate a distribution for consumers of noncommercial fish. The distribution is based on the 7-day recall data on fish consumption. Persons who did not consume noncommercial fish during the recall period were excluded from the distribution. Although Burmaster et al. (1994) do not describe it in these terms, the distribution represents a distribution of fish consumption by people who fish above a certain frequency. It is not possible given the nature of the data to determine the average fishing frequency of those excluded from the survey. The short-term recall survey methodology does not capture usual consumption for each individual as Burmaster et al. (1994) discuss. For chronic risk assessment, it would be better to have a survey that captured usual consumption. However, most if not all distributions used in risk assessment suffer from this problem. Burmaster et al. (1994) determined that a lognormal model fit the empirical data well. The mean and 95th percentile of the angler fish consumption for self-caught fish are 45 and 98 g/d, respectively, based on the empirical data.

The San Diego Department of Health Services conducted a survey of fishers fishing the San Diego Bay (SDCDHS, 1990) to identify the demographics of this fisher population and to characterize their noncommercial fish consumption patterns. Only 59 fishers provided all of the necessary data for calculating individual noncommercial fish consumption rates and subsets of the 59 interviews were used to calculate species and ethnic-specific rates. We did not utilize this study to determine fish consumption rates because of the small number of subjects in the study population, and therefore a lack of statistical power.

The California Department of Health Services is currently conducting an extensive intercept study of the San Francisco Bay. However, these survey data are not yet available.

9.4 Determination of Fish Consumption Distribution

9.4.1 Choice of Study

The data from the Santa Monica Bay Seafood Consumption Study (SCCWRP and MBC, 1994) were determined to be most appropriate for our estimation of average daily noncommercial fish consumption for marine fish. The study was chosen because it was the most recent well-conducted study of a California population. We obtained the raw data on consumption rate in g/day and number of times fished in the last month in Santa Monica Bay by subject number. A problem with this study is that it does not address the fish consumption rates of children, which presumably would be less.

9.4.2 Statistical Correction for Unequal Sampling Probabilities

Samples obtained from intercept surveys can provide estimates of the distribution of fish consumption rates for the total angler population being sampled. In order to obtain unbiased estimates for the total angler population in the Santa Monica Bay study, the estimates need to be adjusted for sources of unequal sampling probabilities, including: (1) fishing frequency, leading to avidity bias (U.S. EPA, 1997), (2) different frequencies of site selection, (3) different proportions sampled relative to all those then at the site, and (4) different intensities of sampling days on the weekend compared to week days.

9.4.2.1 Calculation Methods

The calculations provide estimates of fish consumption rates in the form of empirical distribution of fish consumption for all anglers and the mean and its standard error for each distribution. In addition to the surveyed distribution, two bias-corrected distributions are calculated. The present analysis uses a probability sampling approach (Jessen, 1978), which Thomson (1991) used to correct for avidity bias to estimate the mean and its standard error for fish consumption rates. For computational simplicity we assume that the angler population was “sampled with replacement” as an approximation. In other words, those sampled once may be sampled again with the same probability as all others in the angler population. Seven of the people surveyed had actually been surveyed previously, an observation supporting the assumption of replacement. Also, for the large population of anglers in this survey, any effect of the removal actually occurring instead of replacement is expected to be small.

The bias-corrected estimation of the empirical distribution of fish consumption rates requires estimates of the probability of each individual being sampled and the consumption rate for that individual. The four-factor sampling probability is proportional to: (1) the fishing frequency obtained in each interview, (transcribed from the answer to the question, "How many times have you fished in the last 28 days?" plus one time for the interview; thus, the number of previous fishing trips are combined with the fishing trip on the day of the interview.); (2) the number of times the contact site was sampled during the year; (3) the proportion of successful interviews at that site on the day of contact, where the denominator was the maximum of (a) those in the census at the beginning of the day's interviews at the site and (b) the number of attempted interviews; (4) the number of weekend days sampled during the year divided by 2 or the number of weekdays sampled during the year divided by 5, whichever applies to the day of contact. The number of weekend days sampled in this study was equal to the number of weekdays sampled.

For the four-factor corrected case, the product of these four quantities gives an overall proportionate measure of size of the probability of sampling each individual for each of the quantities. To construct the corrected empirical distribution, the individual records are first sorted by consumption rate. Each individual contribution to the empirical distribution is proportional to the reciprocal of the measure of size, and the constant of proportionality is fixed by requiring that all these reciprocal contributions must sum to one. These contributions are accumulated by consumption rate to obtain the corrected empirical distribution. This gives the cumulative proportion of all those sampled who consume at a rate less than the specified value. This cumulative proportion is also an estimate of the cumulative proportion for the entire angler population that is being sampled.

For comparison, the correction for avidity, using only the first factor, is calculated similarly, using the reciprocal of fishing frequency to determine the proportional contribution. The uncorrected case uses equal contributions from all individuals

The mean rate of fish consumption for the overall angler population is estimated as (Jessen, 1978; Section 8.7):

$$Z_m = E(Z) / E(N) = \Sigma(Z_i / M_i) / \Sigma(1 / M_i) \qquad \text{(Eq. 9-4)}$$

where: $E(\cdot)$ = the estimate of $(\cdot)$,
Z = the random variable for total rate of fish consumption over all individuals,
Z_i = the rate of fish consumption for the *i*th person sampled,

N = the random variable for the total number of anglers,
Σ is the sum over n, the number of anglers sampled.

The variance of the mean consumption rate is estimated as:

$$\text{var}\{Z_m\} = Z_m^{\,2}\,[\,(s_{Z/M})^2 / Z_m^{\,2} + (s_{1/M})^2 - 2\,s_{(Z/M)(1/M)} / Z_m]\,/n \qquad \text{(Eq. 9-5)}$$

where:

$(s_{Z/M})^2 = M_m^{\,2}\,\{\Sigma\,(Z_i / M_i)^2 - (\Sigma\,Z_i / M_i)^2\,/n\}/(n-1)$,
$(s_{1/M})^2 = M_m^{\,2}\,\{\Sigma\,(1 / M_i)^2 - (\Sigma\,1 / M_i)^2\,/n\}/(n-1)$,
$(s_{(Z/M)(1/M)})^2 = M_m^{\,2}\,\{\Sigma\,(Z_i / M_i)\,(1 / M_i) - (\Sigma\,Z_i / M_i)\,(\Sigma\,1 / M_i)\,/n\}/(n-1)$.
M_m = the mean measure of size of the probability over those sampled.

9.4.2.2 Results for the Santa Monica Bay Study

The empirical distribution curves for the rate of fish consumption for all anglers who caught fish are shown logarithmically in Fig. 1. For comparison to the correction using all four factors, points of two other empirical distributions are shown. The points of the two bias-corrected curves are generally close to each other while the points of the uncorrected curve for anglers surveyed are substantially to the right of the corrected relationships in the upper tail.

Fig. 2 shows the same relationships using z-scores of the angler proportions on the vertical axis. The z-scores are the standard normal variates that correspond to each proportion. The bend in each curve shows that the empirical distributions depart substantially from log-normality, which would produce straight-line relationships.

The results for the estimates of the mean and its standard error are given in Table 9.1 for the three distribution curves. The uncorrected mean is about 70% greater than the value of the corrected means, which differ by only about 3%. The standard error of the uncorrected mean is about the same as that of the mean corrected for avidity. The standard error of the mean corrected for four factors is about twice that of the mean corrected only for avidity.

Table 9.1 Comparison of Four Factor Correction, Avidity Bias Correction Alone and Uncorrected Santa Monica Bay Survey Data

Correction	**Mean**	**Standard error**
Four-factor corrected	30.5	8.6
Avidity corrected	29.4	4.4
Uncorrected	49.7	4.7

9.4.2.3 Discussion

The uncorrected mean is higher than the corrected means because the correction for avidity bias is crucial to compensate for the increase of fish consumption rates with frequency of fishing, a relationship that was calculated but not given here. The marked differences in the upper tails of the corrected distribution curves compared to the uncorrected curve are similarly explained. The increase in standard error of the distribution corrected by four factors is because some of the sites were selected seldom, so the four-factor correction required giving them greater weight.

The determination of the most appropriate denominator for the proportion successfully interviewed at each site is problematic. The population at each site sometimes fluctuated markedly during the half-day interviewing period, but the only data taken for this purpose were the initial census and the number of interviews attempted. The use of the maximum of these two numbers was chosen because the proportion of successful interviews sometimes exceeded the initial census. As a sensitivity check, a four-factor corrected distribution was also computed using the number of attempted interviews as the denominator, which caused that proportion in that distribution to fall at most 2.5 percentage points below the chosen distribution at about the median value.

9.5 Statistical Treatment

OEHHA evaluated the distribution of fish consumption rates from the Santa Monica Bay study after correcting the data for bias as described. We fit the corrected data with a parametric model using Crystal Ball® version 4, an Excel® add-on program that performs Monte Carlo simulations. This lognormal parametric model matches the percentiles of the empirical data reasonably well (Table 9.6; Figures 9.3 and 9.4). The Anderson Darling Statistic is 133.

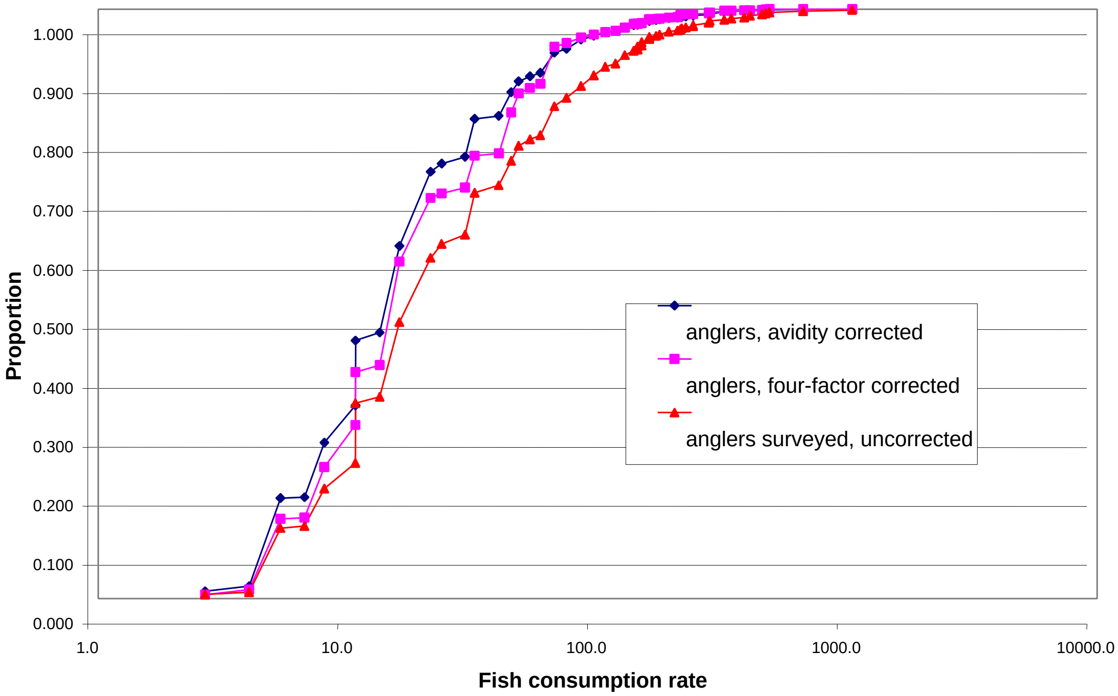

Figure 1. Empirical Cumulative Distributions for Anglers Who Caught Fish -- Horizontal Scaled by Logarithm Of Fish Consumption

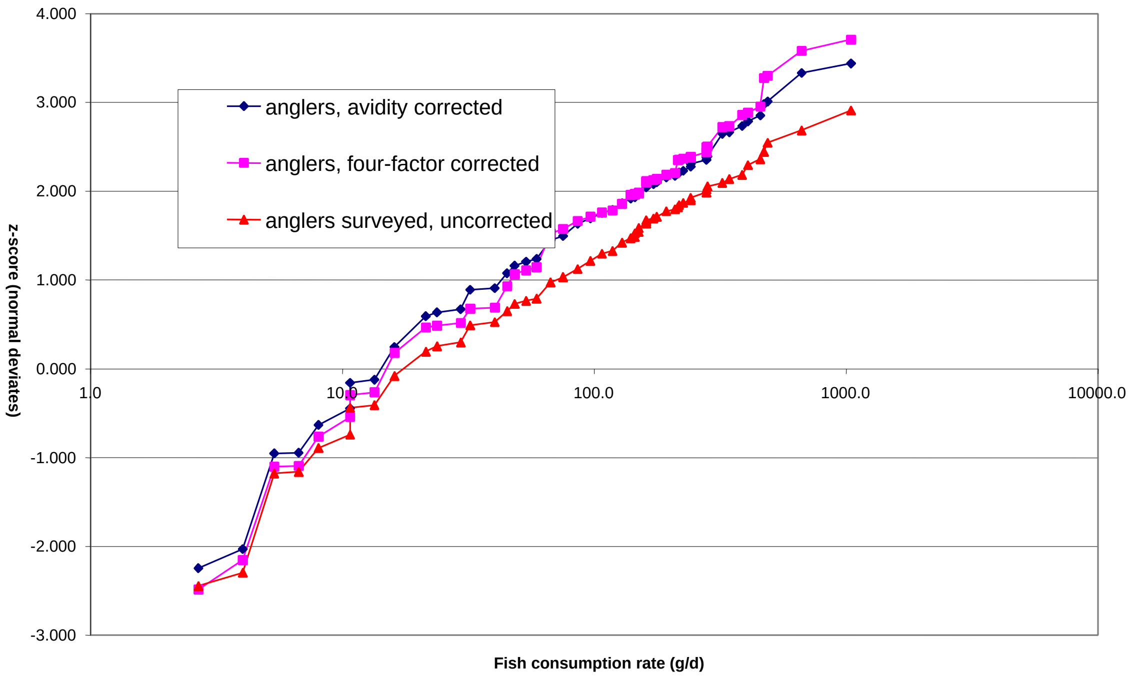

Figure 2. Empirical Cumulative Distributions For Anglers Who Caught Fish -- Horizontal Scaled By Logarithm Of Fish Consumption; Vertical Scaled By Z-Score

9.6 Recommendations

9.6.1 List of "Hot Spots" Chemicals for Which Evaluation of the Fish Pathway Is Recommended

The Air Toxics "Hot Spots" program does not evaluate all chemicals by multipathway analysis. Rather, as described in Appendix E, we have chosen to evaluate those semi-volatile compounds that may be deposited over time. In addition, if the chemical has a long half-life, the multipathway analysis becomes more important. Table 9.2 lists compounds on the Air Toxics "Hot Spots" list for which we propose to require multipathway exposure analyses in the Air Toxics "Hot Spots" program.

Table 9.2 Substances Recommended for Fish Pathway Analysis.

4,4'-methylene dianiline
creosotes
diethylhexylphthalate
hexachlorocyclohexanes
hexachlorobenzene
PAHs
PCBs
pentachlorophenol
cadmium & compounds
chromium VI & compounds
inorganic arsenic & compounds
lead & compounds
mercury & inorganic compounds
mercury & organic compounds
dioxins and furans

9.6.2 Point Estimates of Fish Consumption for Individual Cancer and Noncancer Risk Estimates for Those Who Consume Fisher-Caught Fish.

For the AB-2588 program, OEHHA is recommending that an average value of 0.48 g/kg-day and a high-end estimate of 1.35 g/kg-day be used as point estimate default values of noncommercial fish ingestion rate for the 9-, 30- and 70-year exposure scenarios (Tables 9.3). These values are the mean and 95th percentile, respectively, from our empirical distribution of fish consumption based on the Santa Monica Bay data. There were no data available to ascertain noncommercial fish consumption rates of children. We therefore assumed that noncommercial fish consumption rate would be proportional to body weight. Table 9.4 presents the point estimates in g/day for informational purposes. These can be obtained by multiplying the point estimates in g/kg-day by the time-weighted average body weights of 18 kg for 0-9 year olds and 63 kg for 0-70 year olds. The values in Table 9.3 are used to calculate individual cancer risk and noncancer chronic risk to those who eat noncommercial (fisher-caught) fish. The risks should be presented using the high-end estimate in Tier 1 and 2 risk assessments, if the fish ingestion pathway is a dominant pathway. As noted in Chapter 1, dominant pathways are defined as the two pathways contributing the most to cancer risk when high-end estimates of intake are used in the risk calculation. The risks estimated from the average value would be used where fish ingestion is not a dominant pathway and may also be presented for comparison in assessments where fish ingestion is a dominant pathway.

Table 9.3 Default values for Fisher –Caught Fish consumption (g/kg-day)[a]

	9-, 30- and 70-Year Exposure Scenario
Average	0.48
High-End	1.35

[a] Values obtained by dividing the mean and 95th percentile estimates by 63 kg, the time-weighted average body weight for 0 to 70 years. Since no data are available on fisher-caught fish consumption in children, the assumption is made that the fish consumption would be proportional to body weight. Thus these estimates normalized to body weight would apply to the 9-year exposure scenario where children specific values are used.

Table 9.4 Default Values for Fisher Caught Fish Consumption (g/day)*

	9-Year Exposure Scenario (children)[a]	**30- and 70-Year Exposure Scenario**
Average	8.7	30.5
High End	24.3	85.2

[*] Since the 9-year exposure scenario represents children, we have chosen to multiply the grams/kg-day by the ratio of the time-weighted average body weight of 18 kg for 0-9 year olds for the 9-year scenario, and of 63 kg for 0-70 years for the 30- and 70-year scenarios.

9.6.3 Stochastic Approach to Risk Assessment

OEHHA is recommending the avidity-bias corrected distribution derived from the SCCWRP and MBC (1994) data for use in Tier 3 and 4 risk assessments (Tables 9.5). A lognormal parametric model can be used for this distribution with a mean and standard deviation of 0.48 and 0.71 g/kg-day, respectively. The $\mu \pm \sigma$ is equal to exp (-1.31 ± 1.08). The lognormal parametric model is derived by dividing the fish consumption distribution parametric model parameters in (g/day) by 63 kg so that the units are g/kg-day. This distribution is recommended for the 9-, 30- and 70-year exposure duration scenarios.

The SCCWRP and MBC (1994) study is subject to avidity bias because it is designed as an intercept survey, and thus over-samples frequent fishers. This is mitigated to some extent by the fact that the survey was conducted over a year with multiple visits to the same site. However, we corrected the distribution for avidity bias as noted in Section 9.4.2. in order to obtain unbiased estimates for the total angler population (that is infrequent as well as frequent fishers) in the Santa Monica Bay study. In addition, we corrected for three other biases, which were small, related to sampling frequency of a specific site, proportion of successful interviews, and weekend versus weekday sampling. We also provide a distribution normalized to time-weighted average body weights for ease of use in assessing dose and risk (Table 9.5). This was obtained by dividing through the distribution in g/day by 63 kg, the time-weighted average body weight over a 70-year lifetime. The 9-year exposure scenario is meant to cover the first 9 years of life. However, fish consumption data are not available for children. Assuming that fish consumption is proportional to body weight for both children and adults, the distribution in Table 9.5, which is normalized to body weight, can also be used for the 9-year exposure duration scenario.

Table 9.5 Empirical Distribution for Fisher-Caught Fish Consumption Expressed in g/kg-day for Use in 9-, 30-, and 70-Year Exposure Scenarios.

Mean	SD	p05	p10	p20	P25	p30	p40	p50	p60	p70	p75	P80	p90	p95	σ±μ
0.48	0.71	0.07	0.08	0.12	0.13	0.17	0.21	0.24	0.27	0.47	0.51	0.69	0.99	1.35	Exp (-1.31± 1.08)

Table 9.6 Comparison of Parametric Model and Empirical Distribution Moments and Percentiles *

	Moments and Percentiles (Gm/day)	
	Empirical Distribution	**Lognormal Parametric Model**
Mean	30.5	28.6
Std Dev	45.0	33.1
Skewness	5.72	4.04
Kurtosis	58.1	31.7
$\mu \pm \sigma$		$\exp(2.93 \pm 0.92)$
%TILES		
Sample Min	2.7	
5	4.4	4.16
10	5.0	5.80
20	7.7	8.75
25	8.5	10.1
30	10.9	11.6
40	13.5	15.0
50	15.0	19.2
60	17.5	24.6
70	29.6	31.8
75	32.1	36.5
80	43.3	42.7
90	62.4	64.2
95	85.2	89.0
Sample Max	1045	

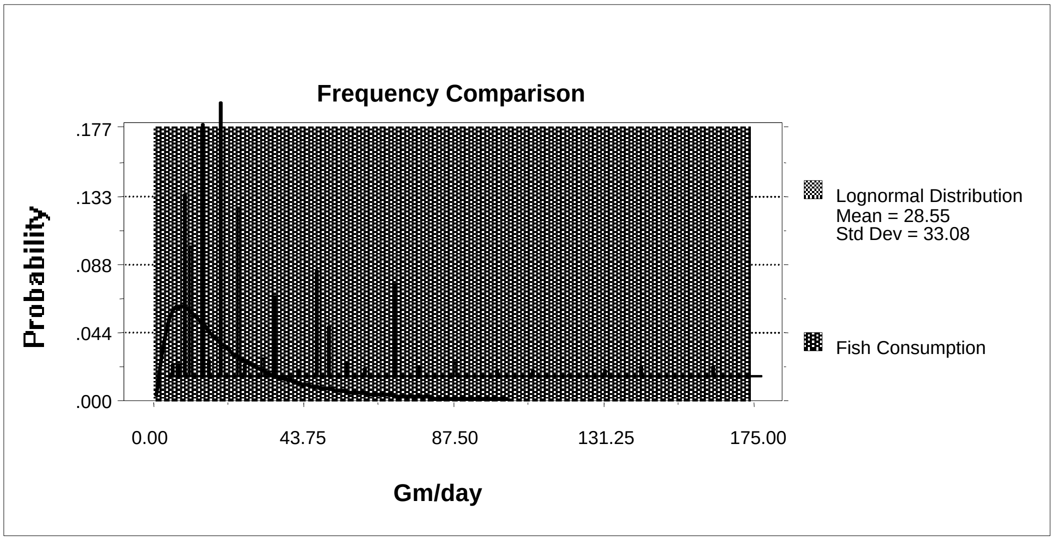

Figure 9-3. Probability Distribution of Fish Consumption and Parametric Lognormal Model.

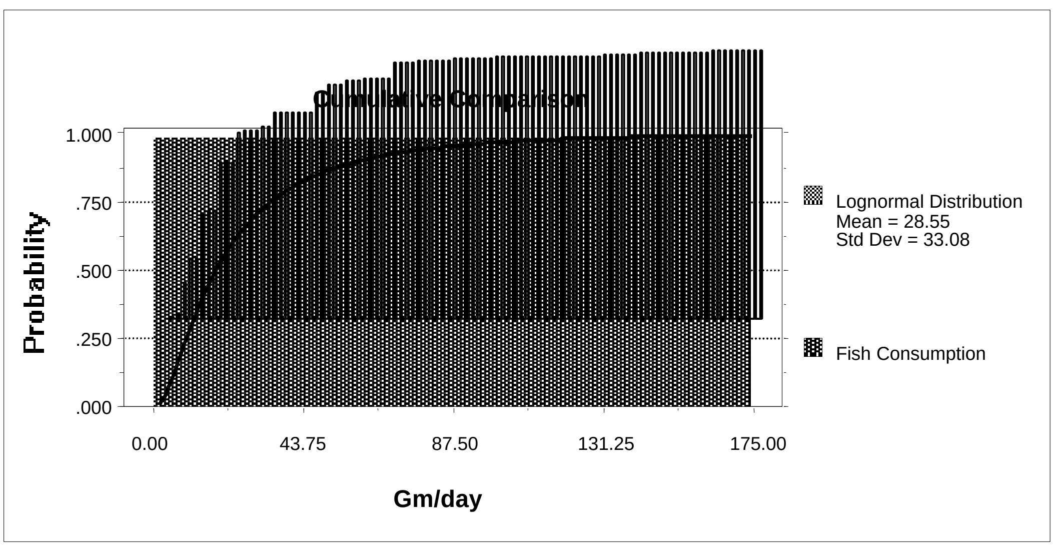

Figure 9-4. Cumulative Probability Distribution of Fish Consumption and Parametric Lognormal Model.

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